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Blind estimation of pharmacokinetic parameters in cardiac DCE-MRI

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Introduction

Myocardial blood flow estimation in DCE-MRI requires measuring the time course of contrast agent concentration in both the blood pool and myocardial tissues. The differences in signal enhancement in these two regions can complicate the imaging process. This problem has been overcome by performing two studies (dual bolus) with differing contrast agent concentrations.

Purpose

This work presents a novel application of the alternating minimization with model (AMM) method to cardiac perfusion data. We estimate the AIF directly from myocardial tissue curves, eliminating the need for perfusion data acquisition at two different concentration levels.

Methods

Dual bolus dynamic cardiac MR data was obtained with low (0.004 mmol/kg) and higher (0.02 mmol/kg) doses of Gd-BOPTA. The images were registered spatially and myocardial voxels were identified manually to obtain a set of tissue activity curves (TACs). The TACs were clustered into 12 curves and input to the AMM method to estimate a parameterized AIF. The estimated AIF was scaled such that the average value of the final three data points was equivalent to the measured high-dose AIF. The extended Tofts-Kety model was used to calculate kinetic parameters pixel-wise in the myocardium using both the directly measured AIF from the low-concentration scan and the AMM estimated AIF.

Results

Figure 1 shows the estimated AIF is slightly lower and more dispersed in time with respect to the scaled low-concentration AIF. This dispersion may be due to dispersion as the CA travels from the LV blood pool to the myocardial tissue and/or flow effects. As seen in Fig 2, the blindly

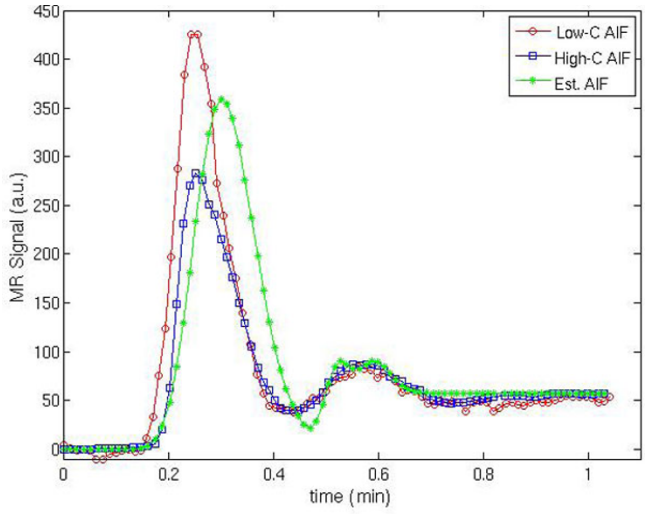

Figure 1
AIFs measured from low concentration (red circles), and high concentration (blue squares) doses in cardiac DCE-MRI. AIF measurements for both scans were obtained from an ROI in the LV blood pool. The AIF estimated from the AMM algorithm is also shown (green asterisks).

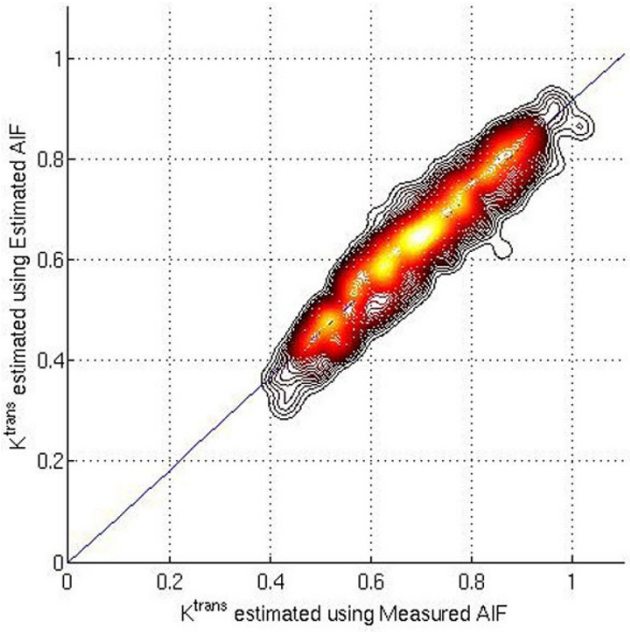

Figure 2
A kernel density plot comparing the Ktrans values obtained from the scaled, low-concentration, measured AIF (x-axis) and the AMM-estimated AIF. In both cases Ktrans was determined voxelwise using a linearized form of the extended Tofts-Kety model.

estimated kinetic parameters tend to be slightly lower (92%) than those from the dual bolus method. The line of best fit shown in blue has the equation y = 0.92x - 0.001 with an r2 value of 0.95.

Conclusion

The AMM blind estimation technique has the potential for simplifying quantitative myocardial perfusion studies. More studies are needed to refine the method and determine its robustness.